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SURVEY OF DEVELOPMENT OF WIRE BROADCASTING IN USSR

This report attempts to give an over-all picture of the development of wire broadcasting in the USSR. It traces the historical development of wire broadcasting, describes briefly equipment used in the systems, and discusses recent developments. The report also makes a quantitative estimate of the total number of radio receiving units in the USSR.

Numbers in parentheses refer to the appended bibliography. The figures referred to herein are appended.

I. GENERAL ACCOUNT OF DEVELOPMENT OF WIRE BROADCASTING

A. In Large Cities

The wire broadcasting movement began in the USSR in 1925, when the first wired radio center was constructed in Moscow by the labor unions under the direction of A. V. Vinogradov. In the following year, wire broadcasting spread to Leningrad and other large cities of the Soviet Union.(1, 3) The first systems were centralized, i.e., only one amplifying station was used, and many did not even have special distribution networks. In the latter systems, the subscriber's telephone line was used, and programs could be heard only when the lines were free from telephone conversations.(2) A diagram of a centralized wire broadcasting system is shown in Figure 1.(4)

With the continuing increase in the operating radius of the stations and number of subscribers, it became impossible to supply the network from one point because of the high attenuation and distortion associated with long lines. This forced decentralization of the amplifying equipment and a reduction of the load and operating radius of each amplifier. Thus, amplifying substations came into use. Also, separate telephone wires were used to feed the substations and special distribution networks were constructed to connect the subscribers'

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loudspeakers to the amplifying substation.(2, 3) A diagram of a decentralized system is shown in Figure 2. Such simple decentralized systems are suitable for serving small areas with few subscribers, but they have obvious deficiencies from the standpoint of serving larger areas with more subscribers.(4)

B. Spread Into Suburban Areas

With the introduction of the "two-stage" wire broadcasting system in the mid-thirties, it became possible to extend wire broadcasting to suburban areas. In this system, distribution feeder lines are used in addition to the subscriber lines. These high-voltage (120-240 v) distribution feeders supply the subscribers' networks through step-down transformers.(1, 2) A diagram of a two-stage wire broadcasting system is shown in Figure 3. A variation of this system was frequently used in cities with many large apartment houses. Here, feeder lines with taps were used, and the subscriber lines were replaced by the apartment house distribution circuit. This system required the installation of step-down transformers in each apartment house. The transformer was connected either to the feeder itself or to the feeder tap. A diagram of this variation of the two-stage broadcasting system is shown in Figure 4.(4)

One more basic improvement came about with the introduction of the "three-stage" system, which was put into experimental operation in 1939.(1, 2) This system was developed to reduce the number of amplifying substations to a minimum by replacing them with transformer substations wherever possible. This was desirable because it was difficult to ensure continuous operation of the amplifying substations with their decentralized supply system. In the three-stage system, each amplifying substation must supply not only a two-stage distribution system, but must also transmit the audio-frequency power to distant transformer substations, each of which feeds a similar two-stage distribution network. The amplifying substations are connected to the transformer stations by special trunk-line feeders (480 or 960 v). Reserve trunk-line feeders are used to ensure continuous operation of the amplifying or transformer substation in case the main trunk-line feeder or amplifying substation supplying it should break down.(4) Diagrams of a three-stage wire broadcasting system are shown in Figure 5 (1) and in Figure 6.(4)

The cabling setup in three-stage systems is quite complex. In most cases, the programs are fed from the radio broadcast station by cable to the central wire broadcasting station. The latter often contains equipment necessary for remote control of all the amplifying and transformer substations. The central wire broadcasting station feeds the program to all the amplifying substations of the system through suspension lines or unused cable pairs taken from the city telephone network. This transmission is maintained at a low level so as not to interfere with the telephone system. The amplifying substations feed the transformer substations through high-voltage (suspension or cable) trunk-line feeders. If these are of the suspension type, they are strung along pipes erected on the roofs of buildings. The distribution feeders of both amplifying substations and transformer substations are ordinarily suspension lines.(1)

All of the systems described above, whether simple centralized, decentralized, two stage, or three stage, include a "zvukofikatsiya" (installation of loudspeakers in streets, squares, etc.) system, the lines of which feed powerful loudspeakers which are installed in streets, squares, parks, and other open spaces. Special programs, and also local air defense signals (in wartime), are transmitted on these lines.(4)

The choice of a two- or three-stage wire broadcasting system depends on the size of the city and the number of subscribers. Two-stage networks, supplied from one or two amplifying substations, are used in most rayon centers and cities with populations of up to 50,000, of whom 8,000-10,000 are subscribers. Either

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two-stage or three-stage systems may be used in cities having populations of 50,000-250,000. In either case, several amplifying substations are generally used. Three-stage systems with trunk-line feeders are generally employed in cities with over 250,000 residents. Such systems may include from 2 to 20 amplifying substations and up to 70-80 transformer substations. The three-stage system ordinarily has each transformer substation supplied from two amplifying substations, and the transformer substation switches automatically from one to the other when necessary.(1)

C. In Rural Areas

Wire broadcasting is accomplished in rural areas by three basic methods, i.e., (a) by a feeder network supplied from wire broadcasting amplifying substations in large cities, (b) by interkolkhoz wired radio centers, or (c) by small kolkhoz wired radio centers. (5, 8) If the first method is employed, one or several local feeder lines similar to the city distribution feeder, are constructed. Each supplies the subscriber lines of several populated points (occasionally several dozen) and may be quite long. A step-up feeder transformer is installed at the input of each feeder line and the subscribers' lines are connected to the feeder through step-down transformers located at the subscriber's home. A diagram of a rural feeder system is shown in Figure 7.(4)

Although the first-named method is the predominant one in the introduction of wire broadcasting into rural areas, economic factors are taken into account before a certain rural area is radiofied from the feeder network.(5, 6) For example, in regions of Moscow Oblast which are within a radius of 12-13 km from a rayon center, the kolkhozes are radiofied from the network of the Ministry of Communications. But if a kolkhoz having only 20-30 homes is located more than 3 km from the feeder line, it is radiofied by receivers.(6)

A typical example of the use of interkolkhoz wired radio centers is found in the Znamya Revolyutsii Kolkhoz, Lgov Rayon, Kursk Oblast, where a wired radio center with a 500-w amplifier drives approximately 300 speakers in each of the seven kolkhozes it serves.(7)

The third method of bringing wire broadcasting to rural areas, and one that has proved increasingly popular of late, is the installation in kolkhozes of small economical centers with powers up to 5 w, which supply 30-50 speakers. This method is considerably cheaper from the equipment and power supply standpoint than individual receivers, and eliminates the need for constructing long feeder lines from a central amplifying substation.(5)

II. EQUIPMENT USED IN WIRE BROADCASTING SYSTEMS

A. Equipment Used in City Systems

The equipment of a large city wire broadcasting system includes the central wire broadcasting station, the amplifying substations, the transformer substations, and the distribution network, including trunk-line feeders, distribution feeders, and subscribers' lines.

The central wire broadcasting station includes all the equipment required for transmitting the audio power to the amplifying substations and for controlling all elements of the system. The entire Moscow Wire Broadcasting System is remotely controlled from the central station, which is operated by three technicians per shift. The power of the amplifiers in the central wire broadcasting station is determined basically by the number of amplifying substations which it supplies. The amplifiers must have the following characteristics: band pass response of 50-10,000 cps with a variation of ± 1 db; harmonic content in this band of 1-1.5%; and noise level of -65 to -70 db.

The amplifying substations in large cities are usually installed in special buildings. They are supplied from their own internal step-down transformer unit. The equipment includes the amplifiers and the switching and control equipment. The power of the amplifying substation is calculated on the basis of 0.5 w per subscriber loudspeaker. Thus, with the continuing increase in the number of subscribers served and the introduction of two- and three-stage systems, the power of amplifying substations has increased correspondingly. The first amplifying substations had power of 2 or 3 w. Then units for 30 w and 200 w were constructed, and later the power of units increased to 500, 1,300, 3,000 and 6,000 w.(1) A 36-kw station was equipped in Moscow in 1944 - 1945, a 50-kw wire broadcasting station was put into operation in Kiev in 1946, and a 30-kw station was constructed in Khar'kov in 1947.(1, 2) In addition, powerful wire broadcasting stations have been constructed in Rostov-on-Don, Tbilisi, and many other cities. In 1949, 60-kw substations were put into operation in Moscow; each such substation can supply audio energy to 100,000 subscriber loudspeakers.

The transformer substations have two step-down transformers rated at 5-10 kw (one at the end of each high-voltage trunk-line feeder, i.e., main and reserve feeders) and units for switching, signaling, and protection. The protective elements of the transformer substation operate together with those of the amplifying substation and disconnect the high-voltage from the trunk-line feeders if the conductors break or short circuit or if the quality of the insulation deteriorates sharply.(1)

The subscriber's loudspeaker unit commonly includes the loudspeaker itself, a transformer, a volume control, and a limiter /current-limiting resistor/ or fuse.(4) The loudspeaker most commonly used is the Rekord.(15) Piezoelectric loudspeakers were used for a time during the war, but it was found that they were not sufficiently durable. In city wire broadcasting networks, limiters are often connected in both sides of the line, as shown in Figure 8.(4) For radiofication of streets, squares, etc., the R-10 loudspeaker is most frequently used. This is a permanent-magnet electrodynamic speaker which draws 10 va, has a frequency response of 250-4,000 cycles, and operates at temperatures from -40 to 50° C.(9, 10)

B. Equipment Used in Rural Systems

In areas which cannot be radiofied from networks of the Ministry of Communications (i.e., by the use of rural feeder lines), wire broadcasting is accomplished by the use of kolkhoz or interkolkhoz wired radio centers having powers ranging from 2 to 1,000 w. The wire broadcasting equipment described is not classified as kolkhoz or interkolkhoz center equipment, because most of it is suitable for use as either. All of these units can be used to transmit either from the local studio (by microphones or phonograph), from the receiver, or from the feeder line, if there is one in that particular location.(10, 14)

Some of the equipment used in rural wire broadcasting systems is described below. This list is not complete, but is intended to give a general idea of the types and sizes of wired radio centers used. Many wired radio centers are built by radio amateurs, and thus have no type designations and may have odd power ratings.

The largest center ordinarily used in rural wire broadcasting is a 500-w unit.(20) The commercial type number of this unit is unknown, but examples of its use are quite numerous.(7) The output power can be increased quite readily, however, and amplifiers of different ratings may be used occasionally, depending on the needs of the community.(10, 13) For example, a 1,000-w interkolkhoz wired radio center has been built in the village of Rozhdestvenno of Molotov Rayon.(11)

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Another unit frequently used as an interkolkhoz center is the KTU-100. This 100-w unit is supplied from a 110-, 127-, or 220-v line and drives up to 400 Rekord loudspeakers and two R-10 street loudspeakers. One source states that the KTU-100 includes a Vostok receiver (10), which has long-, medium-, and two short-wave bands (32), although another source reported that the Rodina receiver was used in the KTU-100's he serviced.(33) The Rodina, however, is also an all-wave receiver.(34) The TUB-100 is similar to the KTU-100, except that it is designed for nonelectrified regions and operates on storage batteries.(10)

Other units in operation are: the line-operated UK-50, which includes a Vostok receiver, and drives 200-250 Rekord loudspeakers and one R-10 street loudspeaker (10, 30); and finally, two 20-w units -- the VTU-20 for nonelectrified regions and the UTS-48 for electrified regions. The former has its own wind-driven generator (type of receiver is unknown) (10). The UTS-48 is supplied from the line and includes a ten-tube all-wave PTS-47 receiver which has four short-wave bands, one general (40-75 m) and three with band spread (30.6-32.35 m, 24.8-26 m, and 19-20.3 m).(12) Both the VTU-20 and the UTS-48 can drive approximately 120-150 Rekord loudspeakers.(10)

In November 1950, it was announced that wired radio units of the "MGSRTU" (small, stationary, wired radio equipment) series with output powers of 50 and 100 watts had been developed to replace the UK-50 and KTU-100. These units can be operated on a 110-, 127-, or 220-v line and include a "PTS-47-S" receiver.(14) In June 1951, it was announced that the Institute of Radio Broadcasting, Reception, and Acoustics (IRPA) had developed a 2-watt radio center, already in production, which could be operated from the line, from storage batteries charged by a wind-driven generator, or from dry batteries.(15) The description of this equipment states that it can drive up to 50 of the new economical SG-1 electrodynamic loudspeakers. The receiving-amplifying section of the KRU-2 has long-wave (730-2,000 m), medium-wave (188-577), and short-wave (70-25 m) bands.(16)

The subscriber's unit in rural areas is the same as in city wire broadcasting networks, except that limiters are ordinarily connected in only one side of the line, as shown in Figure 9.(4) In addition, only 0.15 w is allowed per speaker in rural networks (10), whereas city networks are calculated on the basis of 0.5 w per speaker.(1)

III. RECENT DEVELOPMENTS IN WIRE BROADCASTING

Recent developments in wire broadcasting techniques include attempts to provide multiprogram broadcasting to subscribers, the use of telephone lines for remote power supply and control of local kolkhoz centers, the use of cable instead of overhead lines for subscriber's networks, and incorporation of wired radio centers into telephone exchanges.

The main difficulty in the wire broadcasting systems used at present is that the subscriber cannot select his program, but must listen to the one selected at the Central Wire Broadcasting Station (in the case of city networks) or at the wired radio center (in the case of local networks). In 1940 - 1941, experiments in multiprogram broadcasting were carried out by the Leningrad Branch of the Central Scientific Research Institute of Communications (wire broadcasting networks) and by the Moscow Institute of Communications Engineers (lighting networks). The diagram illustrating the system for a lighting network is shown in Figure 10. In this system, a separate transmitter and filter is used for each program. The subscriber's unit must include a preselector filter unit, a detector, and an audio-frequency amplifier. Further development of this circuit in 1948, as applied to rural electrification conditions, made possible the initiation of experimental operation in one of the kolkhozes of Moscow Oblast.(17) An experimental unit for high-frequency multiprogram broadcasting using the wired broadcasting network was put into operation in Leningrad in 1949.(18)

Low-power rural wired radio centers which are supplied from a kolkhoz electric power station often have to discontinue operation during periods of heavy load. On the other hand, many kolkhozes having low-power battery-operated wired radio centers do not have charging units since their cost is comparable to that of the center; consequently, difficulty is encountered in finding suitable power sources to charge the batteries. Thus, to ensure continuous operation of these centers, experiments have been conducted since 1949 on the use of intrarayon telephone lines for simultaneously supplying direct current and the hf program transmission to the low-power centers. In June 1950, it was reported that such a system had been developed and was under test in an experimental section.(18)

In May 1951, work was said to be continuing on the use of intrarayon telephone lines for transmitting broadcast programs to low-power wired radio centers, but no mention was made of remote power supply. According to this report, the Design Bureau of the Ministry of Communications had developed the equipment needed in this system, which includes the transmitter installed in the rayon center and several receiving units. One of the plants of the Ministry of Communications was to produce an experimental set of this equipment in 1951.(15)

Late in 1951, a general system was described for remote power supply and program transmission to low-power rural radio centers. This system is shown in Figure 11. It requires the installation of a battery in the rayon center, and transmission of the 250 v supplied by the battery through the mid-point of the transformer and along the telephone line to the rural radio center. The telephone line is also used for transmission of central broadcast and local broadcast programs to the rural center. The equipment required in the rayon center includes a receiving unit, a wire broadcasting transmitter, and a filter. The rural radio center must be equipped with a transformer, a filter, and a receiver-amplifier unit. The latter unit permits reception of programs either from the telephone line or independently by radio.(19)

Recently, great stress has been laid on the use of underground cables for the wire broadcasting networks of unforested areas.(20) This method was first proposed by A. A. Severov, Chief Engineer, Main Administration of Radiofication, Ministry of Communications USSR.(27) Conductors and cables with polyvinyl chloride insulation (OPTV, PVRM, and PTPV conductors and PRVMP and PRVMCh cables) are generally used for this work (22), and the cost per kilometer of such a line is only about one third that of an overhead line.(20) Special cable-laying machines have also been developed to speed up the work and cut down the man-hours required.(18, 20) In 1949, more than 1,000 km of underground lines were laid.(20) The rapid introduction of the method is shown by the fact that more than 10,000 km of underground lines were laid in 1950.(21)

In connection with the fact that the wages for operating personnel of wired radio centers up to 100 w in power constitute half the operating costs of the center, an attempt was made in the Latvian SSR to reduce these costs by incorporating the wired radio centers in telephone exchanges. Technical maintenance of the center and wire broadcasting lines was combined with maintenance of the telephone switchboards and telephone lines. Operational responsibility for both the telephone exchange and the wired radio center was vested in one person. Successful operation with small centers led to experiments with the incorporation of larger centers, and in 1949, 1,000-w wired radio centers were installed in telephone exchanges of Yelgava, Yekabpils, and Ogra. Experiments with this system have also been conducted in the Estonian and Lithuanian SSR and in some republics and oblasts of the USSR.(23)

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IV. RADIO AUDIENCE IN USSR

There are estimated to be approximately 10 million loudspeakers connected to wire broadcasting networks as of 1 January 1951. This figure is based on the fact that there were 6 million wired loudspeakers in 1940 (8), and, at the beginning of the postwar Five-Year Plan, there were approximately 6.2 million wired loudspeakers.(25) Furthermore, 4 million were scheduled for installation in the postwar Five-Year Plan (26), and one million speakers a year were being added to the networks during the years 1949 and 1950.(18, 27) Thus, by 1951, the Soviets had just succeeded in surpassing the goal which was originally set for 1 January 1934 in the ambitious 1929 - 1933 five-year plan for radiofication which was intended to give firm foundation to the slogan "Radio and Motion Pictures Will Replace Vodka and Wine." This plan called for radio receiving units totaling 14 million, including 9.5 million wired loudspeakers, 2.5 million vacuum-tube receivers, and 2.0 million crystal receivers. (24)

In 1940, there were about one million receivers for individual use in the USSR. Thus, the total number of radio receiving units (receivers and wired loudspeakers) was approximately 7 million in 1940.(8) The postwar Five-Year Plan called for a 75% increase over the prewar level in receiving units by 1 January 1951, which would increase the total number of units to 12 million.(25) If 10 million of these units are wired speakers, it must be assumed that there are 2 million vacuum-tube and crystal receivers in use. A considerable number of the receivers produced since the end of the war probably have been installed in rural areas, for it has been stated that radio receivers will account for about 50% of the radiofied "points" in rural radiofication.(29) The figures for Moscow Oblast seem to bear out the latter statement: in 1949, 100,000 points (residences) were to be radiofied (6, 28), 50,000 by the use of crystal and vacuum-tube receivers; in 1950, 225,000 points were to be radiofied, 105,000 from the wired radio network and 120,000 by installation of crystal and vacuum-tube receivers.(28) Also in 1949, it was reported that the Moscow Order of Lenin Radio Plant had begun production of the two-band Moskvich receiver and that the kolkhozes of Moscow Oblast should receive about 60,000 of these in 1949.(6) If this situation is general throughout the USSR (the Moskvich, ARZ-49, and similar receivers are the ones most commonly mentioned in rural radiofication), then it is probable that a good proportion of the receivers used in rural radiofication are of the cheap two-band (long- and medium-wave) type.

The advantages of a wire broadcasting system for civil defense purposes and listener control are obvious. There is a lack of information in regard to economic advantages. However, it is known that when a newly constructed subscriber network is connected to an already existing broadcast network (and no additional amplifying equipment need be added), the cost per loudspeaker of the Rekord type, as of 1949, was about 150 rubles. In 1949, the cost of a cheap crystal receiver of the Komsomolets type, including the antenna, was about 84 rubles.(10) No exact figures are available on the cost of mass-produced vacuum-tube receivers. However, in July 1951, it was stated that the prize-winning receivers (Tula, B-1950, and Standart) in the competition for the development of a cheap battery-powered receiver for rural radiofication could all be sold for 115-130 rubles if mass-produced.(31)

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/Figures follow./

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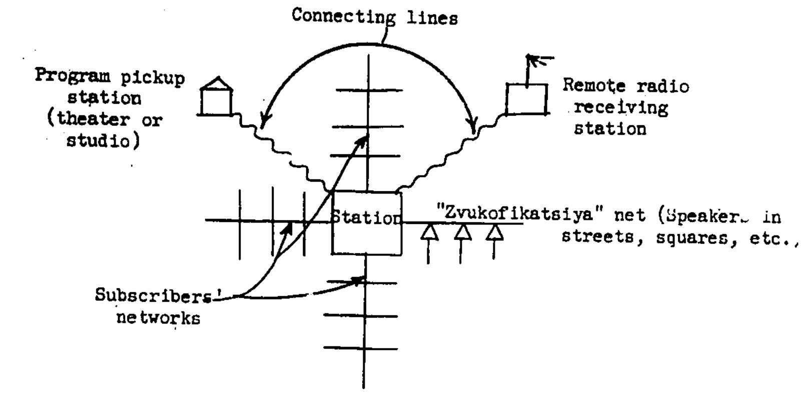

Figure 1. A Wire Broadcasting Network in a Centralized Wire Broadcasting System

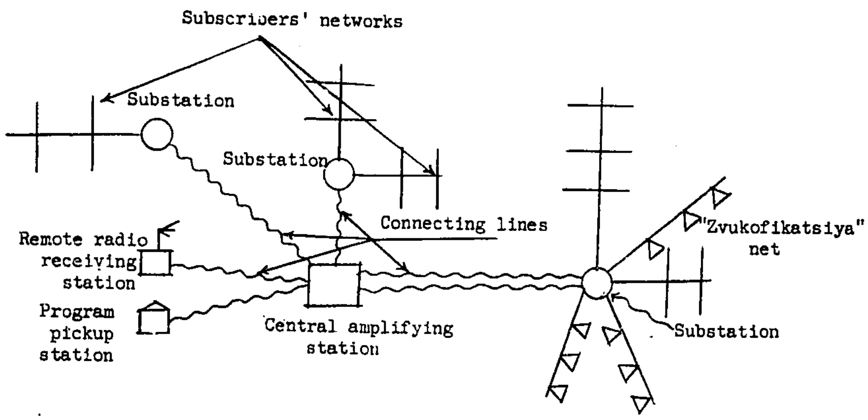

Figure 2. A Wire Broadcasting Network in a Decentralized System

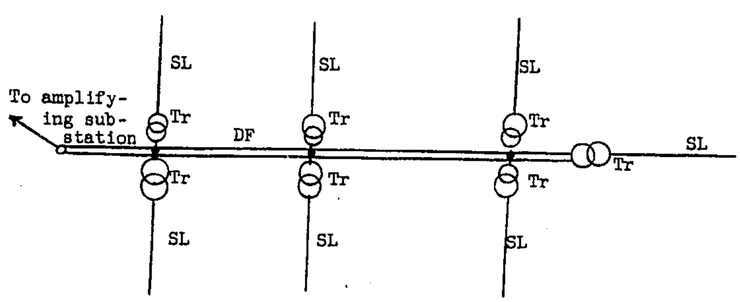

Figure 3. Lines in a Two-Stage Wire Broadcasting Network. SL--Subscribers' Line; DF--Distribution Feeder; Tr--Step-Down Transformer

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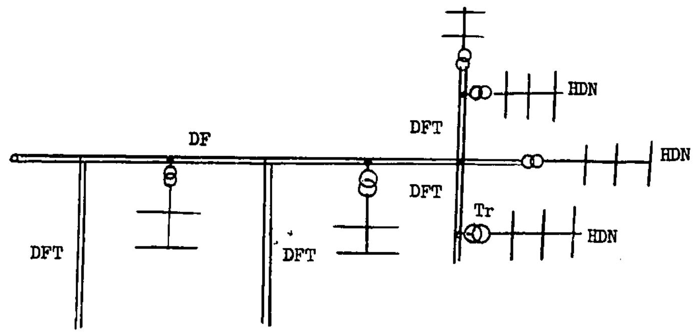

Figure 4. A Distribution Feeder Without Subscribers Lines. DF--Distribution Feeder; DFT--Distribution Feeder Tap; HDN--House Distribution Network Connected to the Feeder or the Feeder Tap Through Step-Down Transformers Tr

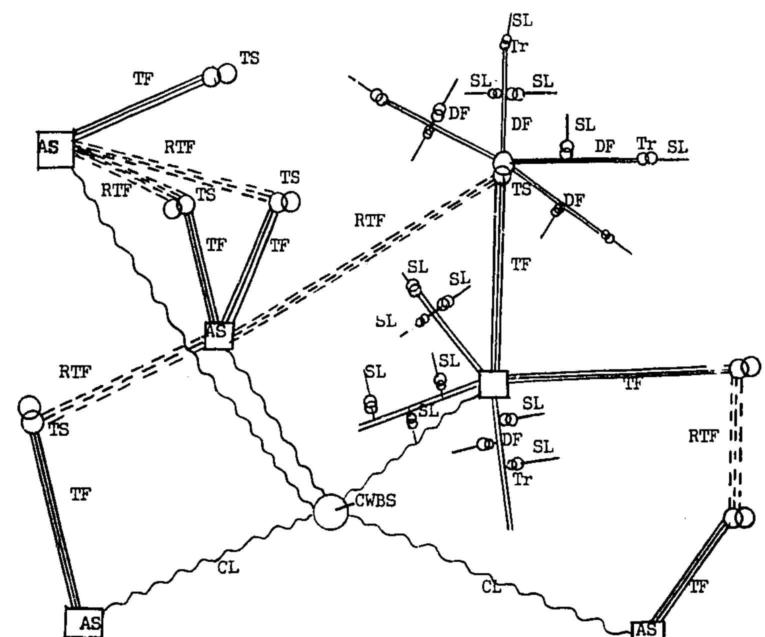

Figure 5. Diagram of a Three-Stage Decentralized Wire Broadcasting System. SL--Subscriber's Line; DF--Distribution Feeder; TF--Trunk-Line Feeder; RTF--Reserve Trunk-Line Feeder; CWBS--Central Wire Broadcasting Station; AS--Amplifying Substation; TS--Transformer Substation; Tr--Step-Down Transformer; CL--Connecting Line

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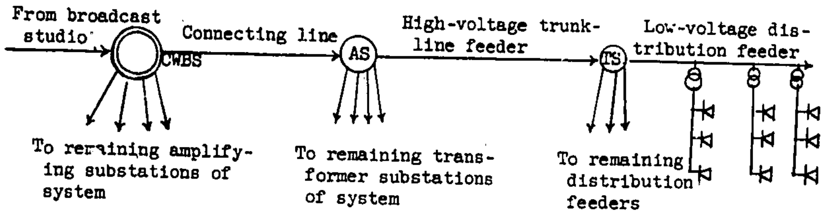

Figure 6. Simplified Diagram of a Three-Stage Wire Broadcasting System

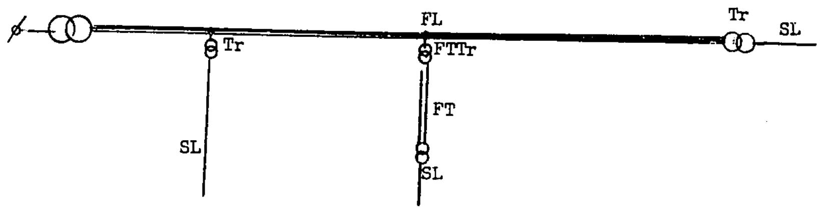

Figure 7. A Rural Feeder System. FL--Feeder Line; FT--Feeder Tap; SL--Subscriber's Line; FTr--Feeder Transformer (step-up); FTTr--Feeder Tap Transformer (step-down); Tr--Subscriber's Transformer (step-down)

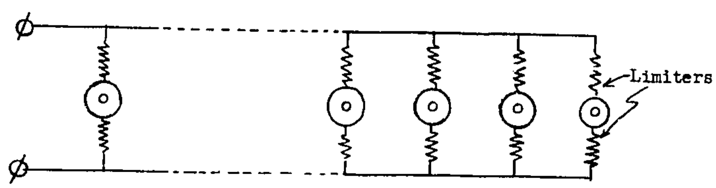

Figure 8. Connection of Subscriber's Units in City Wire Broadcasting Networks (with limiters in both sides of the line)

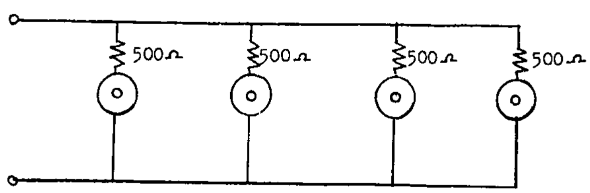

Figure 9. Connection of Subscriber's Units in Rural Wire Broadcasting Networks (with limiters in only one side of the line)

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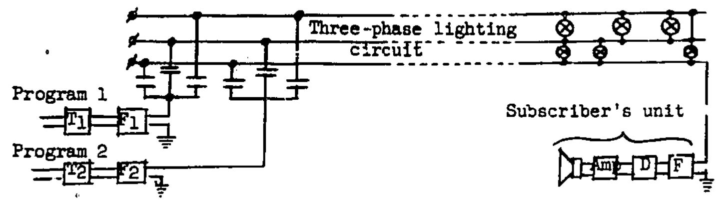

Figure 10. A Multiprogram Broadcasting System Using the Lighting Circuit. T_1 and T_2--Transmitters 1 and 2; F_1 and F_2--Filters 1 and 2; F--Filter; D--Detector; Amp--Audio-Frequency Amplifier

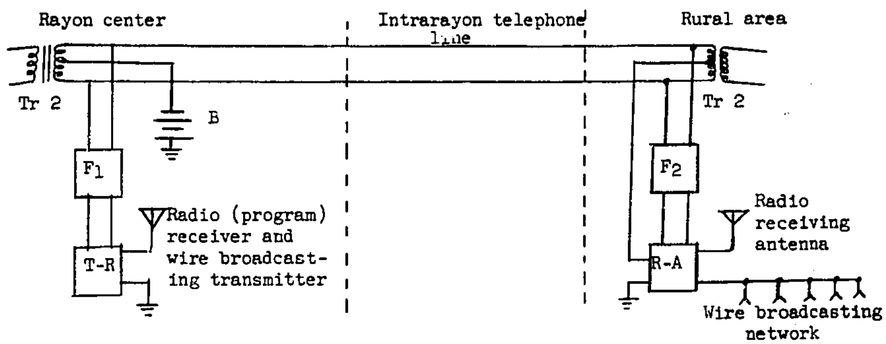

Figure 11. Principle of Supplying and Sending Programs to a Rural Radio Center on an Intrarayon Telephone Line. F_1 and F_2--Filters; T-R--Receiver and Transmission Unit; B--Battery; Tr--Transformer; R-A--Receiver-Amplifier Unit

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